ANALYST REPORT
SMART AGRICULTURE

A new wave of IoT solutions leads the way to more sustainable farming

Global demand for agricultural products is on the rise. By applying advanced technologies in agricultural production, farmers are able to measure and manage the variability of crops in the fields and animals within the herds. Connected equipment, sensors and controllers are being deployed across farms worldwide to increase yield in order to meet the growing demand for food driven by population growth and urbanisation. According to analyst firm Berg Insight's latest research in the space, the agricultural sector is significantly underpenetrated by IoT technologies but set to experience a wave of technology adoption, writes Fredrik Stålbrand, a senior analyst at Berg Insight

Growers have known for a long time that variations in their fields exist, modern technologies have however enabled detailed measurements of such variations. The introduction of global positioning system (GPS) technology in the mid-1990s marked the advent of precision agriculture, as it allows for precise positioning of agricultural machines driving in the field. Today, farmers utilise sensors mounted on GPS-guided equipment along with satellite imaging, soil sampling and in-field sensor systems to collect a wide range of data from their fields. The collected layers of geocoded data form a digital representation of their crop fields and are used for decision support.

Every growing season, farmers have to make about 40 to 50 decisions about each individual field. Across large farms this can easily amount to several thousand decisions per season, which makes it very challenging to stay informed when making those decisions. Farm management software enables analysis and visualisation of field data and is also used to create prescription maps that describe how much product to apply at specific locations across a field. Telematics systems in tractors and combine harvesters allow for seamless wireless data transfer of field and machine data to and from the machines. ▶

Figure 1: Global agriculture in numbers
Source: Berg Insight, 2018

Advanced technologies enable far greater precision in agricultural tasks

One of the most widely adopted solutions in arable farming comprises auto-guidance systems, which have the capability to automatically steer the machine across the field according to a preselected pattern. Auto-guidance systems allow machine operators to focus on the task performed rather than the steering operation. The technology provides greater accuracy and reduces overlaps compared to manual steering, leading to a reduction in fuel consumption, working hours and use of inputs.

The use of precision farming technologies and practices aims to optimise the application of seeds, fertilisers and crop protection chemicals according to conditions in specific zones of the field. For example, it is estimated that uniform application of fertilisers across a field leads to over-fertilisation of roughly 40% of the area, while also causing a reduction in yield by 10%. In precision fertilising operations, higher application rates are used in parts of the field where nitrogen run-off occurs, while lower application rates are employed in other areas. Thus, farmers are able to reduce the consumption of fertilisers as well as increase yield by 10–15%.

Huge range of new sensing solutions

Software and services built on top of sensing hardware have attracted the attention of venture capital firms and input manufacturers which are investing heavily in the space.

According to AgFunder, companies in the farm management software, sensing and IoT segment received US$464m in funding in 2017, up 28% from the previous year. These companies mainly focus on providing solutions for measuring and modelling various conditions in the field to monitor for example weather, soil moisture content, crop performance, diseases and pests.

Historically, farmers have primarily relied on regional weather forecasts from airport weather stations that were infrequently updated. Modern in-field sensor systems can measure weather, soil and crop conditions from more than 40 environmental data parameters at frequent intervals. Local weather monitoring may for example provide insights into fertilisation timing, as heavy rainfall can wash away the applied fertilisers. In addition, weather data can be used for crop management, yield forecasting and disease modelling.

Another area targeted by a number of start-ups comprises remote pest monitoring. Agricultural pests are responsible for significant losses to the world's annual crop production. Traditional pest management is typically a labour-intensive undertaking as it requires manual scouting throughout the crop fields. Moreover, satellite imaging is typically also insufficient due to its infrequency. Modern solutions utilise connected insect traps and data modelling for risk evaluation to time the application of pesticides. ▶

Figure 2: Major smart agriculture applications
Source: Berg Insight, 2018

Machine management
- Remote diagnostics
- Maintenance planning
- Transport management

Precision agriculture
- Guidance and automated steering
- Yield monitoring and mapping
- Precision seeding
- Precision fertilising
- Precision spraying

Remote sensing
- Satellite imagery
- Drone imagery

Remote monitoring and control
- Weather monitoring
- Pest monitoring and control
- Irrigation management

Precision livestock farming
- Cattle monitoring
- Herd management
- Performance monitoring

Machine uptime critical in forestry operations

Forestry shares many of the characteristics of agriculture but differs from crops because of its multi-year lifecycle. The industry encompasses a range of activities including forestry management, harvesting and forest planning and the tasks often require specialised machines such as harvesters, forwarders, bunchers and excavators. Therefore, machine uptime is one of the most critical factors to ensure productivity and profitability.

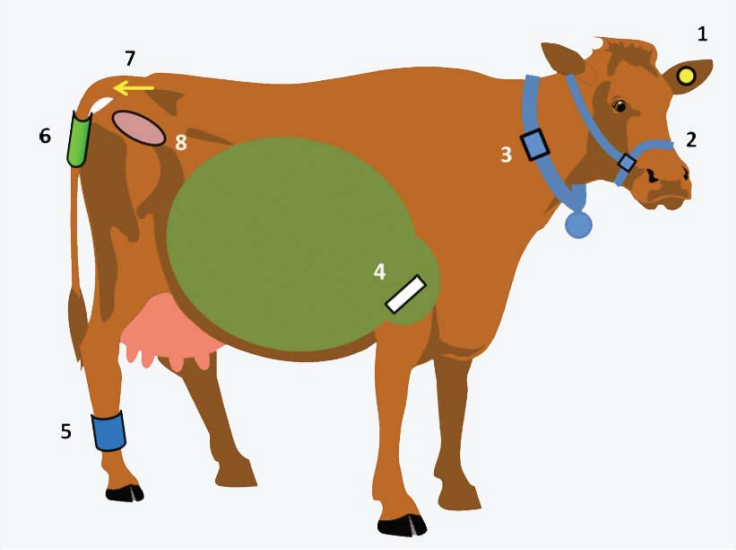
Modern forestry equipment integrates telematics systems that provide functionality for remote diagnostics and maintenance planning. The attachment rate of telematics systems in forestry equipment is markedly higher compared to that of agricultural equipment. Many of the industry incumbents are also active in the construction equipment market and have offered their systems as standard on their range of equipment for many years.

Farm consolidation drives technology adoption in dairy farming

Increased demand for meat and dairy products has resulted in larger herds per farmer, making livestock management and manual observations challenging. In large-scale dairy operations, the ratio of cows per worker is often greater than 200. Large farms have typically made necessary investments in barn infrastructure, automation and radio frequency identification (RFID) to create a stress-free environment that supports larger herd sizes and reduces the need for manual labour.

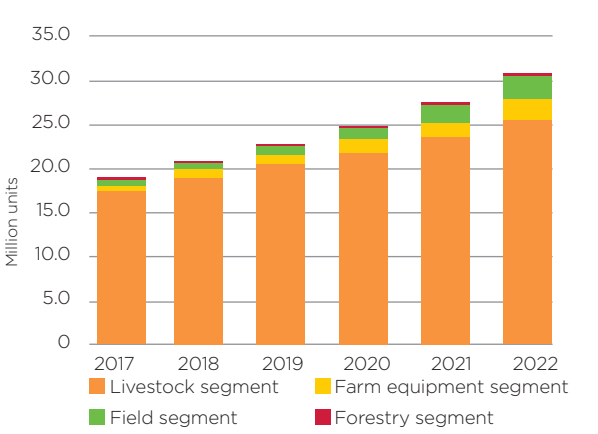
In dairy operations, precision livestock farming technologies are used to optimise the milk yield from each animal. Apart from keeping the herd healthy, a high fertility rate is crucial to maximise efficiency as a large number of non- ▶

Figure 3: Wearable devices for cattle monitoring
(1) ear tag, (2) halter, (3) neck collar with counterweight, (4) reticulorumen bolus, (5) rear leg pedometer, (6) upper tail ring, (7) tail head inject and (8) vaginal bolus



Source: Caja, G., Castro-Costa, A., & Knight, C. (2016). Engineering to support wellbeing of dairy animals. Journal of Dairy Research. 83. 136-147.

Figure 4: Installed base of wireless devices for applications in agricultural production



Source: Berg Insight, 2018

lactating cows results in lower production volumes along with high costs of feed and other inputs. Each additional day a cow remains dry can cost a dairy producer up to US$6 in reduced profitability.

Body-mounted sensor systems together with herd management software are used to achieve satisfactory herd health and timely insemination when a cow is in oestrous. A wide variety of wearable technologies are commercially available to measure a range of parameters in individual dairy cows. The devices can be used for monitoring of behaviour, lameness, mating, calving, rumen function and position.

The installed base of wireless IoT devices in agriculture reached 18.8 million in 2017

Berg Insight estimates that the installed base of wireless devices for applications in agricultural production amounted to 18.8 million connections worldwide in 2017. Growing at a compound annual growth rate of 10.6%, the number of connections is expected to reach 31.1 million in 2022. Wireless sensor systems fitted on livestock account for the vast majority of all connections due to their wide adoption in dairy cow monitoring applications. For data transmission, these systems typically employ 802.15.4-based network technologies, while cellular networks are used in some niche applications. The main application areas for cellular communication comprise telematics and in-field sensor systems. Among the network technologies, LPWA technologies are expected to achieve the highest growth rate and realise a significant market position in the remote monitoring and control segment.

All major equipment manufacturers have initiatives related to precision agriculture and telematics

Most high horsepower machines are today standard fitted with global navigation satellite system (GNSS) receivers and field computers. Yield monitors which collects data on crop yield and moisture content are furthermore present in almost all new combine harvesters. Deere & Company became the first manufacturer to launch a telematics system in 2002 and a number of manufacturers are today offering factory-fitted telematics systems as standard on new agricultural machinery. Telematics has however a long way to go before it becomes mainstream in the industry.

Leading vendors of precision agriculture solutions include the world's largest manufacturer of agricultural equipment Deere & Company, followed by the US-based precision technology vendors Trimble, Topcon Positioning Systems, Raven Industries and Ag ▶

Figure 5: Major vendors active in smart agriculture

Source: Berg Insight, 2018

Leader Technology. Hexagon holds a strong position in the positioning segment through its subsidiary NovAtel. Among the top agricultural equipment manufacturers, AGCO and CLAAS have also developed proprietary solutions, while CNH Industrial and SDF collaborate with third-party companies to integrate precision technologies into their range of agricultural equipment.

Manufacturers of agricultural inputs such as seeds, crop protection chemicals and fertilisers have expanded their software offerings notably in recent years, predominantly through acquisitions. The market for data-oriented applications and agronomic services are also targeted by a host of start-ups. Major providers include the Monsanto subsidiary The Climate Corporation, Canada-based Farmers Edge and the newly formed DowDuPont with its Encirca services.

A group of companies have emerged as leaders on the nascent market for in-field sensor systems that are used for remote monitoring applications. These include Davis Instruments, Pessl Instruments with its METOS brand, Semios, Hortau, AquaSpy and CropX. Although shipment volumes in this segment is still low, the pace of adoption of sensor systems has increased significantly in recent years, predominantly in the specialty crop segment. While the specialty crop segment is small on a per hectare basis, on a value standpoint the segment is very large. The return on investment of remote monitoring solutions has thereby proven to be high.

Dairy equipment manufacturers partner with specialist sensor providers

The traditional dairy equipment original equipment manufacturers (OEMs) including DeLaval, GEA Group, Lely and BouMatic offer comprehensive portfolios of milking robots and feeding systems that enable farmers to scale their milk production through process automation. In order to sell technology to dairy farms, local presence is a necessity and the large manufacturers are supported by distributors and local sales representatives in markets worldwide.

Most OEMs have chosen to partner with smaller, specialised companies to provide advanced sensor technology along with their milking equipment and farm infrastructure solutions. An exception is Swedish DeLaval, which provides a comprehensive portfolio of integrated remote monitoring solutions for herd management along with its dairy equipment. Important providers of sensor systems for herd management include Netherlands-based Nedap and The Allflex Group subsidiary SCR which both sell their systems to a number of leading dairy equipment manufacturers and ▶

genetics companies. Other significant players include Fullwood, Dairymaster and Afimilk which acquired Silent Herdsman in February 2016.

The traditional industry boundaries in the agricultural sector are beginning to blur

Partnerships and consolidation among agricultural equipment manufacturers and precision technology companies marked the theme of the last decade. Alliances are now expanding in scope among agricultural equipment manufacturers, input producers, software companies and agronomic services providers. These relationships take many forms, ranging from transactional agreements based on application programme interfaces (APIs) to more formal and complex relations involving contracts and service-level agreements. Trimble has for example a long-standing technology partnership with CNH Industrial, but also has integration agreements in place with additional OEMs such as AGCO and Deere & Company as well as the input manufacturer DowDuPont.

Moreover, input manufacturers are actively investing in agricultural technology ventures through their corporate venture capital arms. These investments are predominantly driven by strategic objectives rather than financial. With extensive knowhow in plant biology, input manufacturers are positioned to become important providers of crop modelling and prescription maps by incorporating farm management software as part of their offering.

By partnering with companies with complementing capabilities, leading players aim to transform from selling equipment and inputs to selling complete yield optimisation solutions to farmers. Berg Insight is of the opinion that groups of companies working together in ecosystems will be able to capture the most value from precision farming data. Investments in APIs and microservices along with an open IT architecture will be key to the development of technical platforms that can support the flexibility needed in the digital ecosystem that is emerging within the agricultural industry.

The agricultural sector is significantly underpenetrated by IoT technologies

Most farms are still family-run businesses and often employ an informal style of management. The adoption of precision farming solutions and software is demanding growers to learn new farming practices and become more organised. In addition, the increasingly complex ▶

technological environment that farmers operate in demands dealerships to offer a greater extent of services to integrate and support the range of technologies that are utilised in precision farming. This is increasingly addressed by established precision technology companies such as Deere & Company, Trimble and Topcon Positioning Systems that are actively investing in their channel partners to offer enhanced support for their precision farming portfolios. Berg Insight expects that the on-going of farm consolidation trend and increased professionalisation of the industry is likely to continue and result in stronger focus on yield maximisation and cost efficiency, which are proven advantages with using precision technologies.

Fredrik Stålbrand
Berg Insight

About Berg Insight

Berg Insight is dedicated M2M/IoT market research firm based in Sweden. We have been specialising in all major M2M/IoT verticals such as fleet management, car telematics, smart metering, smart homes, mHealth and industrial M2M since 2004. Our vision is to be the most valuable source of intelligence for our customers. Berg Insight can offer numerous market reports, detailed market forecast databases and advisory services. We provide custom research tailored to your requirements including focused research papers, business case analysis, go-to-market strategies and bespoke market forecasting.

Our clients include many of the world's largest mobile operators, vehicle OEMs, fleet management solution providers, wireless device vendors, content providers, investment firms and venture capitalists, IT companies, technology start-ups and specialist consultants. We have provided analytical services to 850 clients in 70 countries to date. If you have any questions about our market report subscriptions and advisory services or simply want to understand how Berg Insight can help you, don't hesitate to contact us at **info@berginsight.com**

www.berginsight.com

BERG INSIGHT